

INDOOR AIR QUALITY ASSESSMENT

**Templeton Town Hall
9 Main Street
Templeton, Massachusetts**



Prepared by:
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Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of James Henry, Health Agent of the Templeton Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Templeton Town Hall (TTH), 9 Main Street, Templeton, Massachusetts. Concerns about mold in the basement prompted the request. On October 4, 2002, a visit was made to this building by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment.

The TTH is a one-story, vinyl-sided structure. The building was originally constructed as the Otter River Elementary School in the 1920s-1930s. The building was renovated in 1999 and converted into town offices. The first floor currently has town offices. The basement is partially dirt floor. Areas in the basement on cement are used for storage (see Picture 1) and the boiler room. Windows are openable throughout the building and appear to be original wooden sash windows.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551.

Results

The TTH has an employee population of 13 and is visited by approximately 25 to 30 people daily. Tests were taken during normal business operations and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were below 800 parts per million of air (ppm) in all occupied offices, indicating adequate ventilation in the building. It is important to note however, that rooms were sparsely populated and/or windows were open in a number of areas, which can greatly contribute to reduced carbon dioxide levels. Carbon dioxide levels in the building would be expected to be higher during winter months, when windows are closed, due to the configuration and condition of the ventilation system.

Fresh air is supplied by fresh air diffusers (see Picture 2) that are connected by ductwork to several air handling units (AHUs) located in the dirt floor portion of the basement (see Picture 3). Each AHU is mounted in the ceiling of the basement. Located on the north and south foundation walls are metal hoods that appear to be the fresh air intakes for each AHU (see Picture 4). Fresh air intakes are connected to each AHU by ductwork.

Return ventilation is drawn into grilles installed on the floors. These grills direct air from offices back to the AHU. Fresh air and return air mixed, and then delivered to each room. The AHUs do not have any means to provide exhaust ventilation.

Exhaust ventilation was originally provided by an ungrated hole located at floor level (see Picture 5). A louver located inside the duct controls airflow. A heating element (see Picture 6) is located above the louver that creates airflow via rising heat called “the stack effect”. The vent that originally exhausted air from the building was sealed (see Picture 7). The abandonment of the exhaust vents essentially prevents air

from exhausting from the building. It appears that the building does not have a functioning exhaust ventilation system. Without exhaust ventilation, normally occurring environmental pollutants can build up and lead to air quality/comfort complaints.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). Please note that the ventilation system, in its condition at the time of the assessment, cannot be balanced.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur,

leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see [Appendix I](#).

Temperature readings ranged from 68° F to 72° F, which were slightly below the BEHA recommended comfort guidelines in a few areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is difficult in an old building without a functioning ventilation system (e.g. abandoned exhaust system).

The relative humidity ranged from 47 to 55 percent in occupied areas, which was below the BEHA recommended comfort range (see Table 1). The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment.

Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

During the spring and summer of 2002, New England experienced a stretch of excessively humid weather during three periods in May, July and August. As an example, outdoor relative humidity at various times ranged from 73 percent to 100 percent without precipitation from July 4, 2002 through July 12, 2002 (The Weather Underground, 2002). According to the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), if relative humidity exceeds 70 percent, mold growth may occur due to wetting of building materials (ASHRAE, 1989).

The basement is used for storage of large amounts of materials, including cardboard and paper products. If these materials are subjected to high relative humidity conditions without drying for several days, it is likely that these materials can become colonized by fungi (mold). Relative humidity measurements in the basement were 24 percent higher than the relative humidity measured outdoors (49%). Increased temperature indoors, as measured in this building, would be expected to have lower relative humidity compared to outdoors. The increase in relative humidity may indicate that a moisture source exists in the building. Several potential sources were considered. These include:

1. Increased relative humidity can be related to occupants in a building without adequate air exchange. (Note: This possibility was ruled out since the basement was unoccupied).

2. If water penetrates through the foundation, moisture may accumulate in the basement. In an effort to improve energy efficiency, fiberglass insulation was affixed to the foundation walls. It appears the purpose of the insulation is to prevent air penetration and heat loss through the foundation (see Picture 8). The paper on the insulation can support mold growth if wetted. The installation of insulation also prevents natural ventilation of the crawlspace that can lead to the accumulation of water vapor. Water exists in the basement, as evidenced by a sump pump in the basement (see Picture 8A).
3. The condensation drains for the building empty near the foundation (see Picture 9). This configuration creates water pooling along the south foundation wall, which may then penetrate through the wall into the basement.
4. Water pooling on the south wall is exacerbated due to landscaping. The ground at the foundation is flat and covered with grass. Rainwater runoff from the south exterior wall can drip onto the grass, enhancing the pooling effect.
5. Opportunities for water penetration through the building envelope exist along the exterior wall/tarmac junction along the north and west walls of the TTH. Large spaces and damaged brick/mortar were also observed in the exterior wall/tarmac junction at the rear of the building (see Pictures 10 and 11). Plants were noted growing in the junction between the exterior wall and the tarmac. Water can gather in the wall/tarmac seam. Freezing and thawing of gathered water can result in damage to the exterior wall, which can result in water penetration into the building.

6. The design of the drainage for the roof makes it prone to overflowing during downpours. The TTH has a flat roof covered with a rubber membrane that is connected to a single ~3' diameter drain (see Picture 12). Under certain conditions, the drain may not be able to drain at a sufficient rate to prevent water overflow from the roof. Overflow can enhance water pooling along the south wall of the TTH.
7. Shrubbery exists in close proximity to the foundation walls (see Picture 13). The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek, J. & Brennan, T.; 2001).

Each of these conditions, in combination with high ambient temperature during the summer, increased relative humidity and possible water sources within the basement, may contribute to moistening of porous materials. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (e.g., carpet) be dried with fans and heating within 24 hours of becoming wet (US EPA, 2001, ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. In order to control possible mold growth, water penetration into the basement area must be minimized.

In order to explain how mold and associated odors/particulates in the basement can migrate into occupied areas, the following concepts must be understood:

- Heated air (from radiators) will create upward air movement (called the stack effect).
- Cold air moves to hot air, which creates drafts.
- As the heated air rises, negative pressure is created, which draws cold air to the heat source.
- Airflow created by the stack effect, drafts or mechanical ventilation can draw airborne particulates into the air stream (i.e. from the basement).
- The opening of the door to the basement at the base to the main stairwell can provide a pathway for air to travel from the basement to the upper floors.

Return vents (ducts that draw air) are depressurized, which can draw to the AHUs through open seams in sheet metal.

Each of these concepts has an influence on the movement of basement odors and/or related particulates up the stairwell. Of particular note is the condition of the ductwork of the return vents of the AHUs. Each return duct appeared to have a seam that was open to the basement (see Pictures 14 through 16). These open seams can draw air, odors, particles and other pollutants from the basement to be distributed into occupied areas. Without an active exhaust ventilation system, these pollutants can accumulate. In addition, penetrations for piping through the basement ceiling/office floors (see Picture 17) can serve as pathways for basement air to migrate into occupied spaces.

Several areas had signs of water damage (see Picture 18). Each of these areas appeared to correspond to junctions between roof structures that attach to the exterior siding of the building. As an example, open seams in the siding were noted above the lower roof of the southeast corner of the TTH (see Pictures 19 and 20). It appears that

these seams were closed with a sealing compound that has eroded, resulting in a hole through which rainwater may pass. Each siding seam should be inspected twice a year to ensure continuity of the siding system to prevent water leaks.

A musty odor was detected in the planning office. As noted previously, during the previous summer was a stretch of excessively humid weather in Massachusetts. As relative humidity levels increase indoors, porous building materials, such as carpeting, can absorb moisture. The moisture content in carpet can fluctuate with increases/decreases in indoor relative humidity and temperature. Therefore, it is important that moist outdoor air introduced by the univent be vented from the building by a mechanical exhaust system. This particular office was not connected to the AHUs and did not have a window-mounted air conditioner, both of which would reduce relative humidity while operating. Without mechanical means to reduce relative humidity, airflow to dry building materials is necessary. Since this office remains locked, moist air pools within this area can subsequently moisten carpet for extended periods of time. As discussed, if porous materials are not dried within 24 hours, mold growth may occur. Once mold growth has occurred, disinfection of some materials may be possible, however since carpeting is a porous surface, disinfection is likely to be ineffective.

A water fountain is located directly above wall-to-wall carpeting. As previously noted, porous materials that are repeatedly wet can serve as media for mold growth. Plants were noted in other areas and can be sources of pollen and mold, as well as respiratory irritants for some individuals. Plants should be equipped with proper drip pans and be located away from the air stream of mechanical ventilation to prevent aerosolization of dirt, pollen or mold.

An exterior door at the southwest corner of the building had significant water damage (see Picture 21). The floor on the interior side of this door is carpeted. If water penetrates through the threshold of this door, the carpet may become wet.

Other Concerns

A photocopier is located in the main office. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). Local exhaust ventilation may be needed in this area to help reduce excess heat and odors.

The attic is insulated with loose insulation (see Picture 22). The access way to the attic is a wood plug that is not airtight. Airflow around this plug may carry insulation fibers into the hallway. Insulation particles can be eye, skin and respiratory irritants and should be contained.

Conclusions/Recommendations

The renovations to the ventilation system in the building have essentially removed any means to provide exhaust ventilation. This minimization of air exchange can result in environmental pollutants concentrating in occupied areas leading to indoor air/comfort complaints.

In order to address the conditions listed, the recommendations made to improve indoor air quality in the building are divided into short-term and long-term corrective measures. The **short-term** recommendations can be implemented as soon as practicable.

Long-term solution measures are more complex and will require planning and resources to adequately address the overall indoor air quality concerns.

Short Term Recommendations

1. Seal all spaces in return ducts.
2. Seal all spaces around utility pipes.
3. Keep the door to the basement closed. Install weather stripping and a door sweep on this door to create an airtight barrier.
4. Remove the carpet from the Planning Office in a manner consistent with US EPA mold remediation recommendations at:
http://www.epa.gov/iaq/molds/mold_remediation.html (US EPA, 2001).
5. Extend the length of the condensation drain a sufficient distance to allow for water to drain downhill away from the foundation.
6. Seal holes in the tarmac/exterior wall junction with an appropriate sealing compound. Repair damaged brick at rear of building.
7. Repair open seams in exterior siding.
8. To prevent moisture penetration into the basement, the following actions should be considered:

- a) Move foliage to no less than five feet from the foundation.
 - b) Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, J. & Brennan, T.; 2001).
 - c) Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek, J. & Brennan, T.; 2001).
9. Examine the fiberglass insulation along foundation exterior for moisture or mold colonization. If mold growth is present, replace the fiberglass. Please refer to recommendations #1 and 2 prior to acting on this recommendation.
10. Remove mold colonized materials stored in the basement where practical. Disinfect non-porous surfaces with an appropriate antimicrobial.
11. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
12. Consider installing local exhaust ventilation in the photocopier area.
13. Install weather-stripping around the edges of the attic crawlspace access way to render airtight.

Long Term Recommendations

1. Consideration should be given to repairing the original exhaust ventilation system. Consult a ventilation engineer to determine whether existing ductwork can be restored.
2. Examine the feasibility of increasing the size of the roof drain.

References

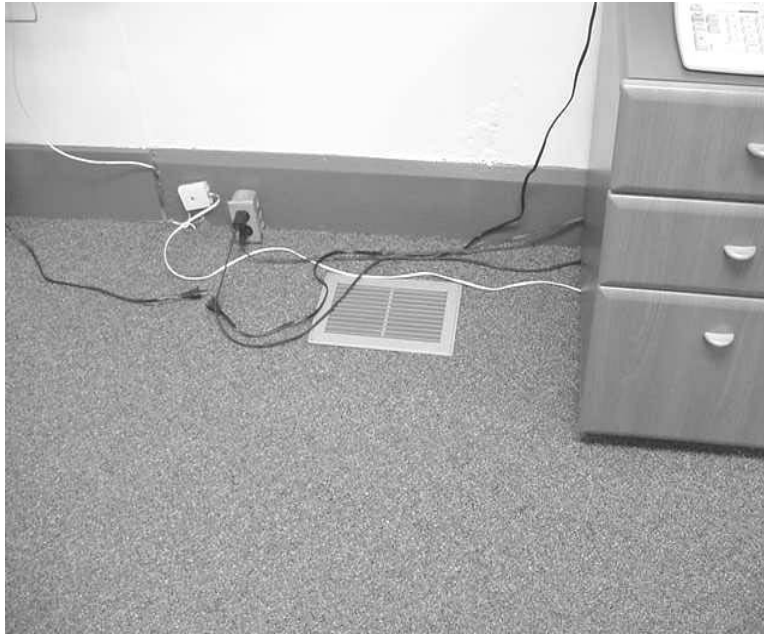
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Picture 1



Storage Of Materials In Basement/Base Of Stairwell

Picture 2



Floor Installed Fresh Air Diffuser

Picture 3



AHU Over Basement Dirt Floor

Picture 4



Fresh Air Intake For AHUs

Picture 5



Exhaust Vent

Picture 6



Heating Element Above Louver In Exhaust Vent

Picture 7



Sealed Original Exhaust Vent

Picture 8



Insulation On Foundation Walls

Picture 8A



Sump Pump In Basement

Picture 9



Condensation Drains On South Wall Of TTH, Note Pitch Of Ground Toward Foundation

Picture 10



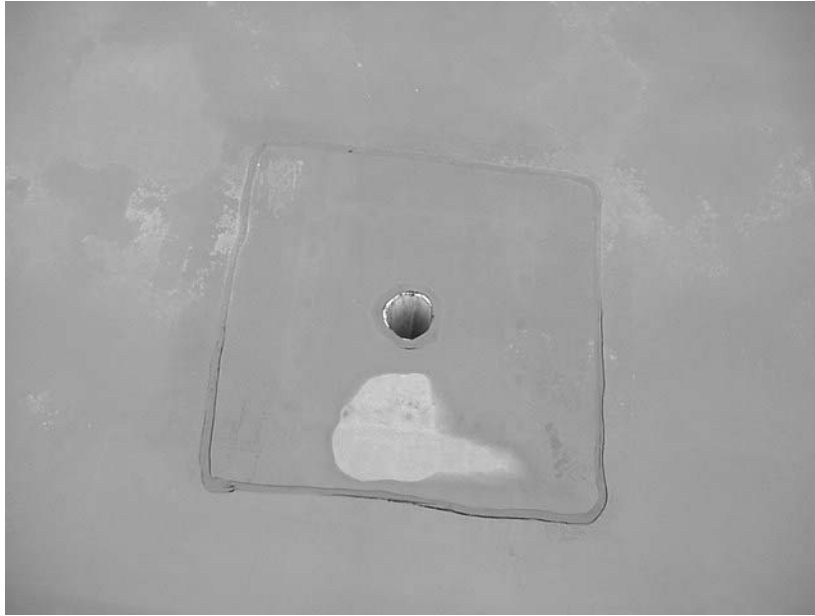
Space In Exterior Wall/Tarmac Junction

Picture 11



Damaged Concrete In Foundation At Rear Of Building

Picture 12



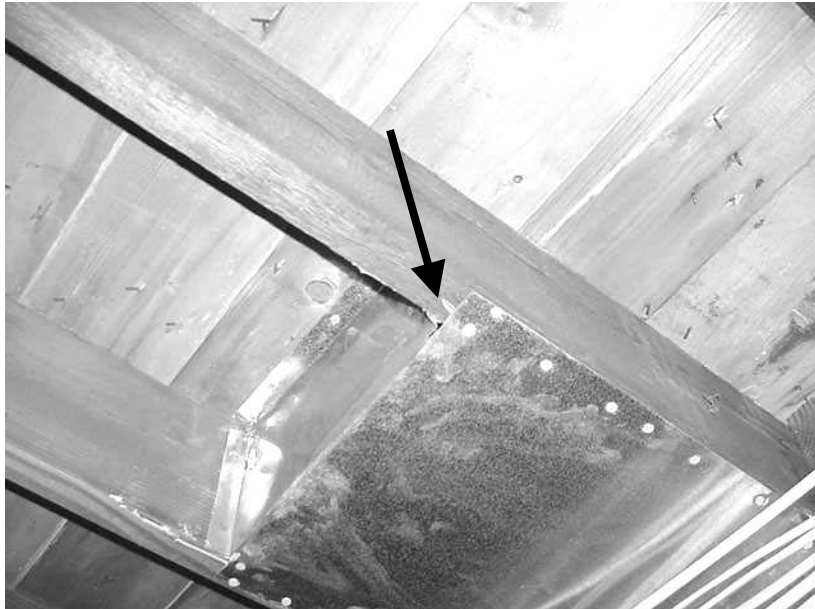
Roof Drain

Picture 13



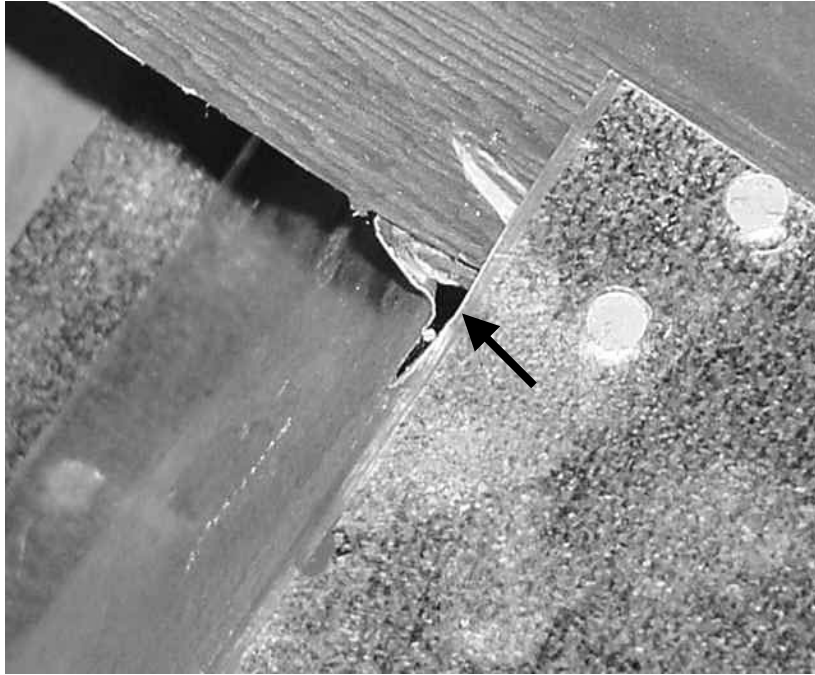
Shrubbery Adjacent To Foundation Wall

Picture 14



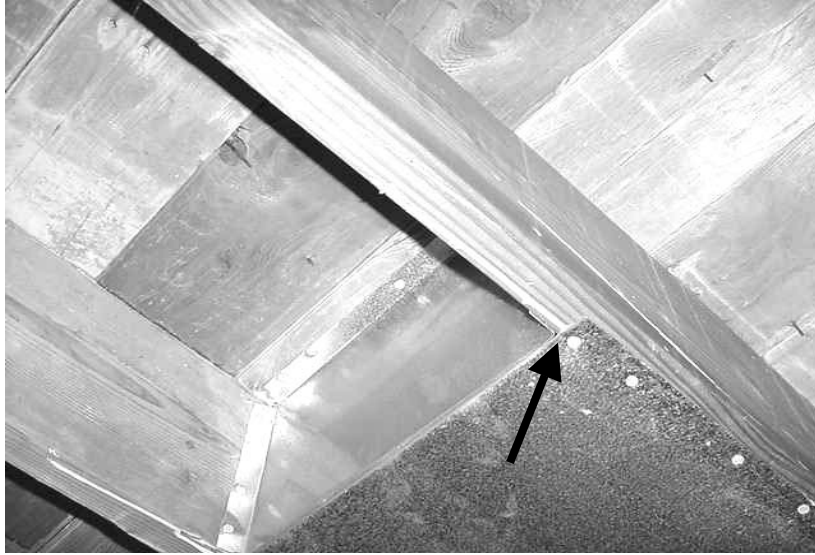
Return Duct Seam

Picture 15



Close-up Of Picture 14

Picture 16



Return Duct Seam

Picture 17



Pipe Penetration Through Floor, Note Light At Hole

Picture 18



Water Damaged Plaster

Picture 19



Siding Above Roof Of Southeast Corner Of Building

Picture 20



Close-up Of Seam In Picture 19, Note Split Caulking

Picture 21



Water Damaged Exterior Door

Picture 22



Loose Insulation In Ceiling Crawlspace

TABLE 1

Indoor Air Test Results – Templeton Town Hall, Templeton, MA – October 4, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	285	58	49					
Health	518	68	55	2	Y	Y	Y	Window and door open Supply/Exhaust off, AT-3, AXV
Building Dept.	678	70	54	1	Y	Y	Y	Supply/Exhaust off Door open
Treasurer	512	70	49	1	Y	Y	Y	Supply ½ sealed Exhaust vault
Town Collector	478	71	48	2	Y	Y	Y	Window/door open, WAC on Supply/exhaust off
Town Clerk	421	70	47	1	Y	Y	Y	Window open, AXV Supply/Exhaust off
Conference Room	569	71	49	8	Y	Y	Y	Supply/Exhaust off, 3 AXV
Assessors Office	487	72	48	0	Y	Y	Y	Supply/Exhaust off Plants, WAC, AXV
Board of Selectman	537	72	49	2	Y	Y	Y	Supply/Exhaust off, AXV Door open
Planning Board	463	71	47	0	Y	N	N	Musty odor
Crawl Space	376	66	73					

* ppm = parts per million parts of air
AXV = abandoned exhaust vent

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%